Modeling Oxygen Production on Mars and Extension to a Human-Scale Mission

Completed Technology Project (2017 - 2021)

Project Introduction

In-Situ Resource Utilization (ISRU) is the identification, collection, processing, and use of local materials to support space missions. It is a concept that has been growing in momentum with humanity's push towards developing a space economy and enabling space exploration. Resources derived from ISRU can be used for life support, construction, propulsion, and energy for both manned and unmanned missions. It has significant potential to reduce the mass, cost, and risk associated with spaceflight. Instead of launching large amounts of consumable materials, space systems can employ ISRU to obtain these materials at the destination site. An example of an in-situ resource is the atmosphere of Mars, which is composed of 96% carbon dioxide. This can be converted into other useful chemicals with appropriate ISRU equipment. The Mars Oxygen ISRU Experiment (MOXIE) is an instrument that seeks to turn the atmospheric carbon dioxide on Mars into oxygen for propellant and life support. MOXIE is a payload being developed for NASA's 2020 Mars Rover, and will produce oxygen from the Martian atmosphere through solid oxide electrolysis (SOXE). The objective of MOXIE is to produce greater than 99.6% purity oxygen at a rate of 10 g/hr ("MOXIE - Mars 2020 Rover," 2016). It is a roughly 0.5% scaled version of a unit that could produce enough oxygen to fuel a Mars ascent vehicle for a future manned mission to the planet. In addition to providing the oxidizer for an ascent vehicle, a scaled version of MOXIE would be able to produce oxygen for breathability, habitation pressure, and ground vehicle propulsion. MOXIE will be the first oxygen-production plant of its kind to travel to another celestial body. As such, it presents a unique opportunity to test ISRU technologies off the Earth. This proposed research studies MOXIE from a modeling and hardware development perspective. The first step will be to improve the software model of MOXIE currently in development at MIT. This will include the incorporation of SOXE data and chemical engineering into the model. The second step will be to compare the performance of an engineering model with the predicted performance of the software model. Physical testing will be conducted with the engineering model at MIT for this purpose. The third step will be to conduct research into potential scale-up and extensibility of the system. The overall goal of this research will be to develop a highly accurate model that NASA can use to map ISRU capabilities for future human exploration missions. The modeling and extensibility research described here are not a part of current NASA or JPL work, which is why this proposal is being submitted for funding consideration. The proposed research on developing accurate models for ISRU technologies like MOXIE is beneficial to NASA on several levels. From a values standpoint, the goal of this research aligns very closely with NASA's core mission and vision to "pioneer the future in space exploration". Along the same lines, this proposal indicates that the Science and Technology Mission Directorate is particularly interested in attracting researchers who are "working on high-priority technologies to sustainably explore space." This research directly contributes to the sustainability of space exploration by demonstrating the extensibility of in-situ production of oxygen on other celestial bodies.

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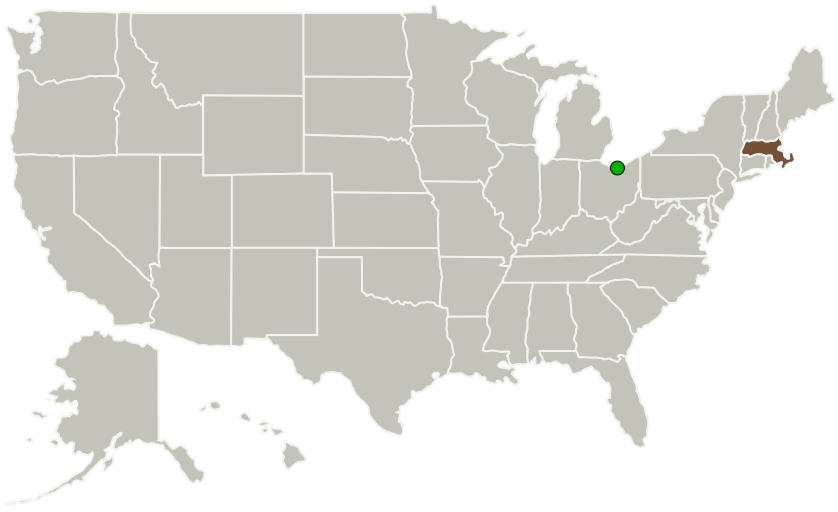
Significant public interest is expected when it is announced that NASA has demonstrated the ability to produce oxygen on the surface of Mars using local Mars resources. At that point, it will be important to understand the extensibility of the system. In addition, by developing technologies like MOXIE that enhance our ability to send humans to Mars and bring them back, our nation will maintain its competitive position as a leader in the international marketplace.

Anticipated Benefits

The proposed research on developing accurate models for ISRU technologies like MOXIE is beneficial to NASA on several levels. The goal of this research aligns very closely with NASA's core mission and vision to "pioneer the future in space exploration". This research directly contributes to the sustainability of space exploration by demonstrating the extensibility of in-situ production of oxygen on other celestial bodies. Significant public interest is expected when it is announced that NASA has demonstrated the ability to produce oxygen on the surface of Mars using local Mars resources. In addition, by developing technologies like MOXIE that enhance our ability to send humans to Mars and bring them back, our nation will maintain its competitive position as a leader in the international marketplace.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Massachusetts Institute of Technology (MIT)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Jeffrey A Hoffman

Co-Investigator:

Eric Hinterman

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Organizations Performing Work	Role	Type	Location
Massachusetts Institute of Technology(MIT)	Lead Organization	Academia	Cambridge, Massachusetts
Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

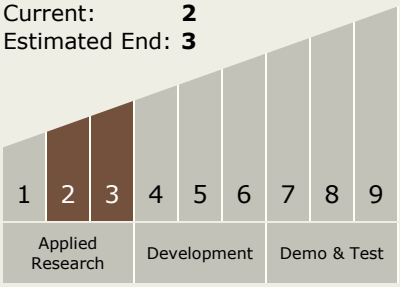
Primary U.S. Work Locations
Massachusetts

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX07 Exploration Destination Systems
  - TX07.1 In-Situ Resource Utilization
    - TX07.1.3 Resource Processing for Production of Mission Consumables

Target Destination

Mars